CITY OF AKRON

Facilities Plan '98

November 1999

Purpose and Background

Under the Ohio EPA CSO Policy, the City of Akron was required to develop a Long Term Control Plan for its combined sewer overflows. As part of this comprehensive planning effort, the City developed five long-term CSO control alternatives that are evaluated and ranked in this memorandum.

The City and its consulting team prepared details for each alternative including water quality benefits, compliance with the CSO Policy requirements, costs, public acceptability, and other related impacts. The City used hydraulic and water quality models to study the water quality impacts related to each of the five alternatives. Detailed information regarding the alternatives and water quality modeling results is presented in separate volumes of the Facilities Plan '98 Planning Report.

The purpose of this technical memorandum is to present the methodology and results of the evaluation of integrated alternatives developed under the City of Akron CSO planning effort. This memorandum is organized in the following manner:

Description of the five integrated CSO control alternatives

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The evaluation methodology

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Results of the analysis

●

Conclusions

Akron CSO Alternatives' Highlights

The City evaluated collection system alternatives of complete separation, express sewers, Ohio Canal interceptor tunnel, Rack 40/parallel outfall sewer, Northside interceptor tunnel, and detention/treatment basins (end of pipe). Also evaluated were Water Pollution Control Station alternatives of additional retention, septage receiving station, tertiary treatment, effluent pumping, disinfection improvements and post aeration. Further, the City investigated non-traditional alternatives of greenway park improvements, setback incentives, stormwater retention and/or treatment, riparian improvements, in-stream aeration, stream restoration and industrial stormwater control.

The City developed five integrated alternatives as part of the CSO Long Term Control Plan integrating the CSO control technologies considered viable for Akron's system: sewer separation, storage/conveyance tunnels, for the Ohio Canal (OCI) and Northside (NSI), and detention/treatment basins (herafter referred to as detention basins for this report). Each integrated alternative was a combination of these technologies. Common to all alternatives, but not listed below (not included in this report) were WPCS retention basins, WPCS disinfection improvements, WPCS post-aeration, Little Cuyahoga River (LCR) stream restoration, and Cuyahoga River (CR) re-aeration structures. The five collection system alternatives were:

Alternative	Description
No.1: System-Wide Sewer Separation	Separation of all combined areas, with the exception of racks (regulators) 31and 40 which will inlcude storage.
No.2: Ohio Canal Interceptor (OCI) and Northside Interceptor (NSI) tunnels plus detnetion basins.	OCI and NSI tunnels, 11 detention basins, Northside Interceptor (NSI) tunnels sewer separation in 7 CSO areas plus detention basins.
No.3: OCI tunnel plus detention basins	OCI tunnel, 15 detention basins, and sewer separation in 7 CSO areas.
No.4: NSI tunnel plus detention basins	NSI tunnel, 18 detention basins, and sewer separation in 9 CSO areas
No.5: Detention basins	22 detention basins and sewer separation in 9 CSO areas

System-Wide Separation

Alternative No. 1

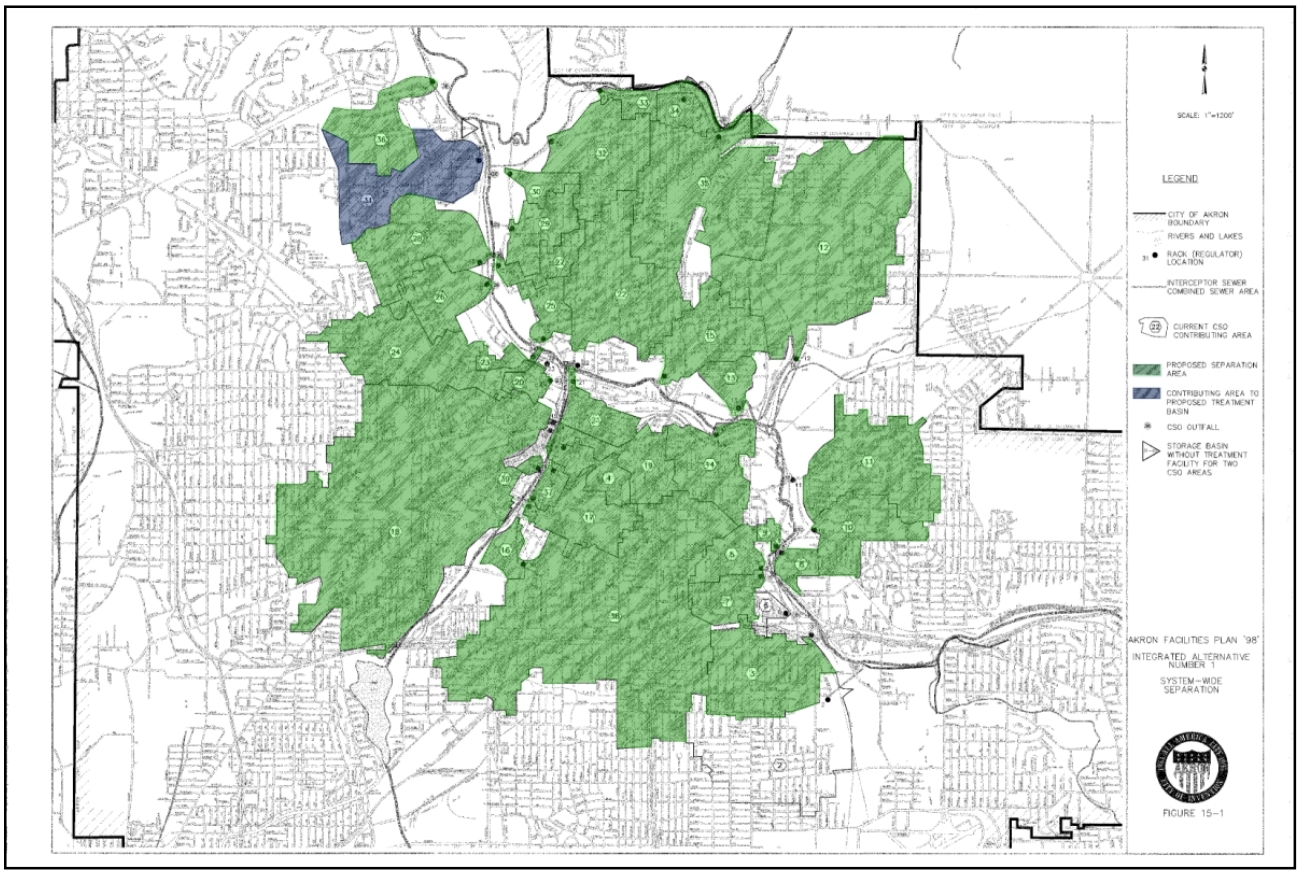


Figure 1

Description

The first of the five integrated alternatives considered in the development of the City's Long Term Control Plan was the system-wide separation of all combined sewer areas with the exception of Rack 31 which was combined with flows from Rack 40 and stored in a detention basin. A Rack is the term used by Akron for a combined sewer overflow regulator.

Alternative No. 1 consists of a detention basin for Racks 31 and 40, and separation of the 35 combined sewer areas tributary to Racks 3 through 39. Sewer separation, in general, consists of the installation of storm sewer throughout the combined sewer area.

Benefits

System-Wide separation eliminates overflows at all but five locations (Racks 14,16,18,29, and the diversion chamber). The basin at Rack 40 and 31 overflows 3 times and bypass at the WPCS occurs 13 times per year. The table below shows the modeled annual quantities of pollutants (CBOD) discharged into receiving waters with implementation of this alternative:

Note that although the combined sewer overflows are reduced, the total storm water inflow to the receiving water is increased substantially (370,000 lbs. of CBOD per year).

Alternative #1 - 1994 Annual Measures of Benefit

Technology/Location	Events (#)	Bypass Hours	CBOD Load (lbs.)
Basins	—	—	—
NSI Tunnel	—	—	—
OCI Tunnel	—	—	—
Separation	20	426	93,677
Additional Storm	–		370,199
Basin 31/40	3	96	77,255
Total in Collection System	**23**	**522**	**541,131**
WPCS Bypass	13	368	255,840

Costs

Costs were prepared in 3 categories for each alternative: Capital costs, operation and maintenance costs, and present worth costs that combine the capital and O&M costs over the life cycle of the facilities taken as 50 years:

- Capital: $998 million
- Annual O&M: $1.2 million
- Present Worth: $869 million

Ohio Canal Interceptor and Northside Interceptor Tunnels with Detention Basin and local Separation

Alternative No. 2

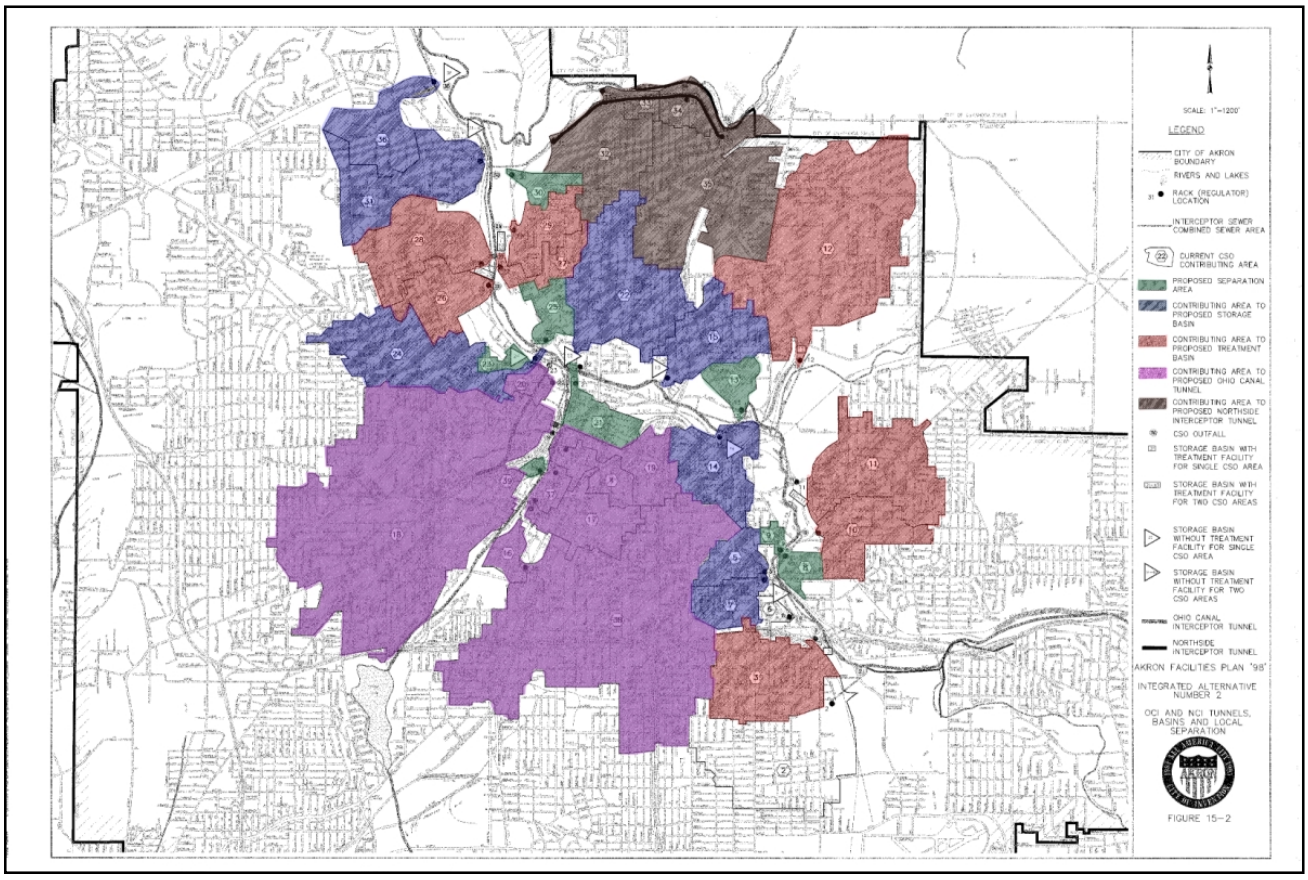


Figure 2

Description

The second alternative is a combination of storage/conveyance tunnels, sewer separation in 7 CSO contributing areas, and 11 detention basins.

The Ohio Canal Interceptor (OCI) Tunnel would serve Racks 4, 16, 17, 18, 19, 20, 23, 24, 37, 38, a portion of 21 and the Northside (NSI) Tunnel would serve Racks 32, 33, 34, and 35. Sewer separation would be performed in areas tributary to Racks 8, 9, 13, 25, 30, 39, and a portion of 21. Detention basins would be constructed for Racks 3, 5/7, 10/11, 12, 14, 15, 22, 26/28, 29/27, 31/40, and 36.

Benefits

The benefits related to construction of this alternative are shown in the table below. Again, the table shows the annual amount of pollutants, determined by the modeling effort, into the receiving waters.

Alternative #2 - 1994 Annual Measures of Benefit

Technology/Location	Events (#)	Bypass Hours	CBOD Load (lbs.)
Basins	79	115	53,913
NSI Tunnel	7	19	15,076
OCI Tunnel	9	81	149,360
Separation	0	0	0
Additional Storm	—	—	15,569
Basin 31/40	4	97	90,833
Total in Collection System	**115**	**362**	**324,751**
WPCS Bypass	50	684	425,140

Costs

- Capital : $175 million
- Annual O&M: 1.4 million
- Present Worth: $188 million

Ohio Canal Interceptor Tunnel. Detention Basins, and Local Separation

Alternative No. 3

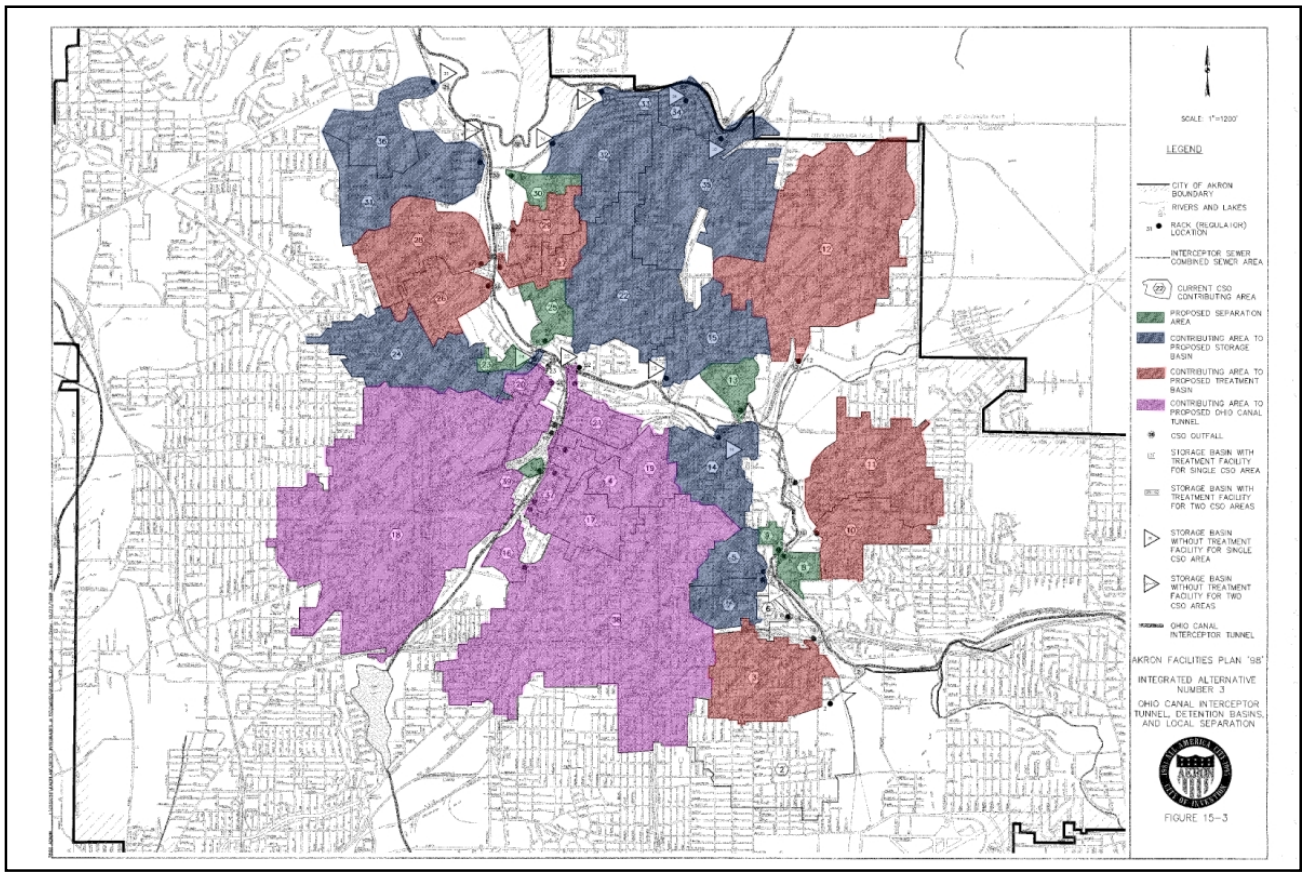


Figure 3

Description

The third of the five alternatives considered in the development of the City's Long Term Control Plan included a storage and conveyance tunnel along the Ohio Canal, separation of 7 CSO basins, and construction of 15 detention basins.

The Ohio Canal (OCI) Tunnel would serve Racks 4, 16, 17, 18, 19, 20, 23, 24, 37 and 38. Sewer separation would be performed in sewer areas tributary to Racks 8, 9, 13, 25, 30, 39, and a portion of 21 and 22. Detention basins would be constructed for Racks 3, 5/7, 10/11, 12, 14, 15, 22, 26/28, 27/29, 31/40, 32/33, 34, 35, and 36.

Benefits

The benefits related to this alternative as modeled by system simulations are presented in the table below. The table shows the amount of pollutants discharged into the receiving waters.

Alternative #3 - 1994 Annual Measures of Benefit

Technology/Location	Events (#)	Bypass Hours	CBOD Load (lbs.)
Basins	102	184	65,561
NSI Tunnel	—	—	—
OCI Tunnel	9	81	149,360
Separation	0	0	0
Additional Storm	—	—	15,569
Basin 31/40	4 to 17	97 to 166	90,833 to 168,560
Total in Collection System	**115 to 125**	**362 to 431**	**321,323 to 399,050**
WPCS Bypass	~50	~684	425,140 to 496,300

Costs

- Capital : $153 million
- Annual O&M: $1.3 million
- Present Worth: $164 million

Alternative No. 4
Northside Tunnel, Detention Basins, and Local Separation

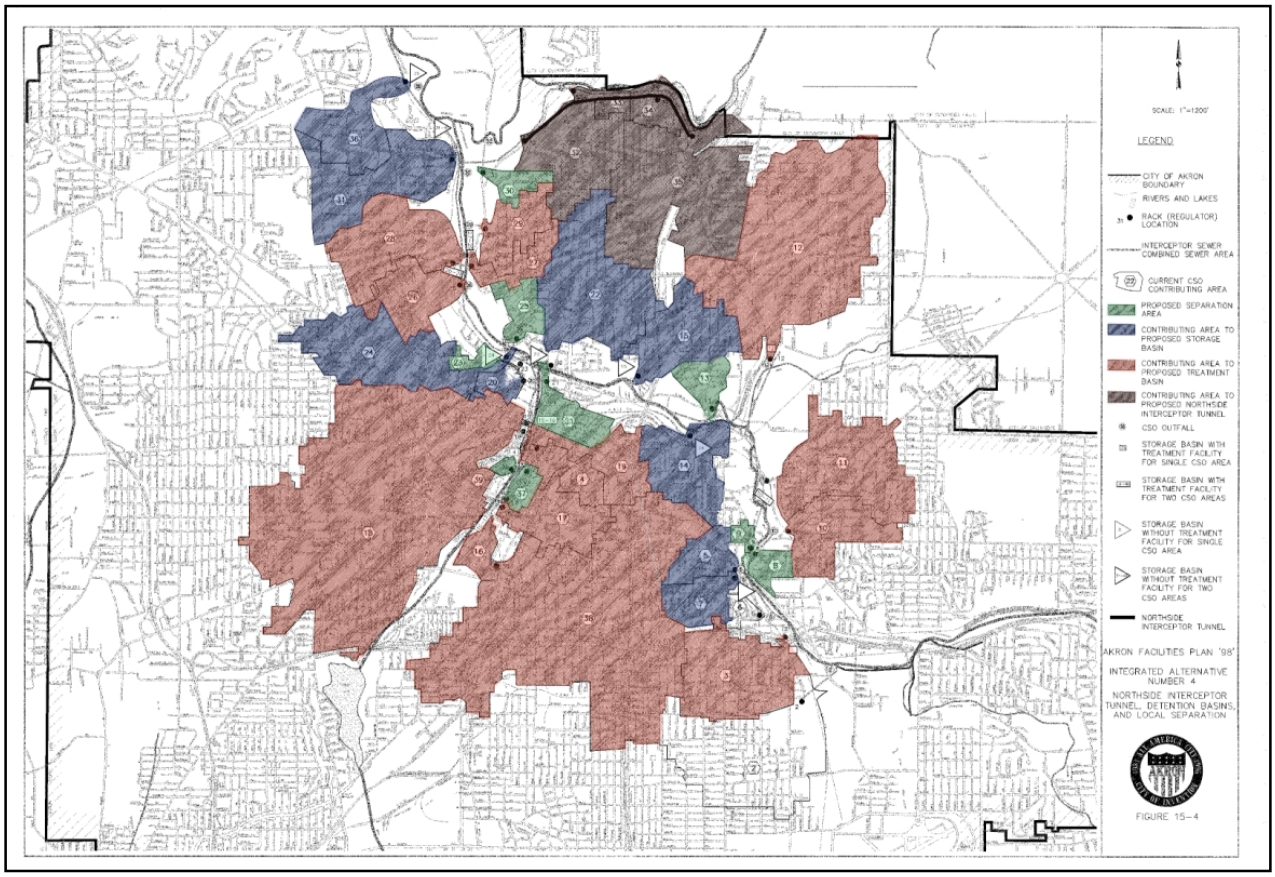


Figure 4

Description

The forth alternative consists of a storage/conveyance tunnel along the Northside Interceptor (NSI), the separation of 9 local CSO contributing areas, and the construction of 18 detention basins.

The NSI tunnel would serve Racks 32, 33, 34, and 35. Sewer separation would be done in tributary areas for Racks 8, 9, 13, 21, 23, 25, 30, 37, 39 and a portion of 22. Detention basins would serve Racks 3,4, 5/7, 10/11, 12, 14, 15, 16, 17/38, 18, 19, 20,22, 24, 26/28, 27/29, 31/40, and 36.

Benefits

Benefits from the simulated modeling results can be seen in the table below:

Alternative #4 - 1994 Annual Measures of Benefit

Technology/Location	Events (#)	Bypass Hours	CBOD Load (lbs.)
Basins	105	161	226,570
NSI Tunnel	7	19	15,076
OCI Tunnel	—	—	—
Separation	0	0	0
Additional Storm	—	—	17,919
Basin 31/40	4 to 17	97 to 166	90,833 to 168,560
Total in Collection System	**116 to 129**	**277 to 346**	**350,398 to 428,065**
WPCS Bypass	~50	~684	425,140 to 496,300

Costs

Costs associated with this alternative are:

- Capital: $ 111 million
- Annual O&M: $ 2.2 million
- Present Worth: $ 145 million

Detention Basins and Local Separation

Alternative No. 5

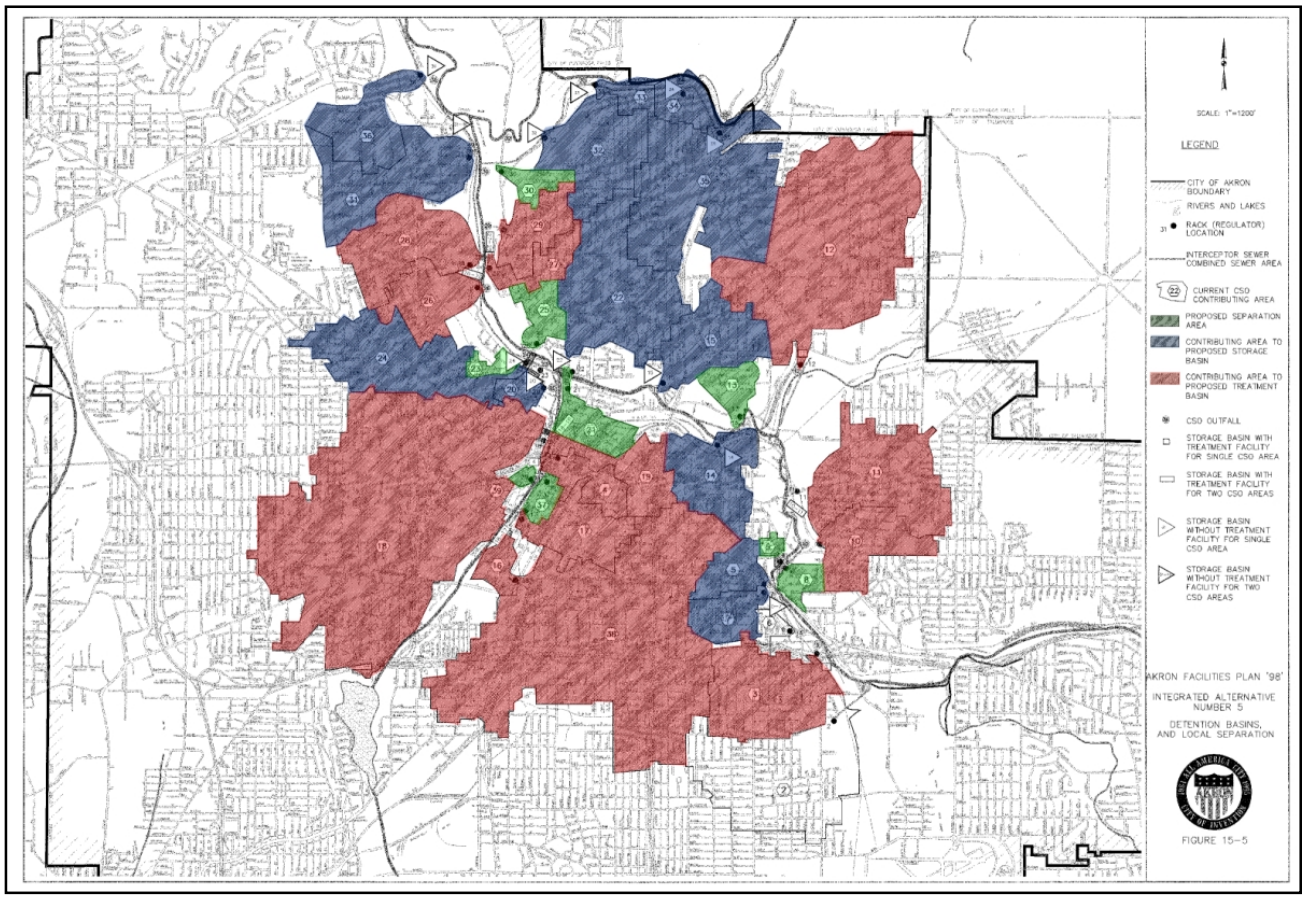


Figure 5

Description

The fifth integrated alternative consisted of sewer separation in 9 CSO contributing basins and the construction of 22 detention basins for the remaining 27 racks. While the separation would be accomplished for Racks 8, 9, 13, 21, 23, 25, 30, 37, 39 and a portion of 22, detention basins would be constructed for the remaining racks for this alternative.

Benefits

Table below shows the benefit related to this alternative for comparison with other four alternatives.

Alternative #5 - 1994 Annual Measures of Benefit

Technology/Location	Events (#)	Bypass Hours	CBOD Load (lbs.)
Basins	128	240	232,149
NSI Tunnel	—	—	—
OCI Tunnel	—	—	—
Separation	0	0	0
Additional Storm	—	—	17,919
Basin 31/40	17	166	168,560
Total in Collection System	**145**	**406**	**418,628**
WPCS Bypass	49	685	496,300

Costs

The estimated costs for this alternative was:

- Capital: $ 90 million
- Annual O&M: $ 2.2 million
- Present Worth: $ 121 million

The Evaluation Methodology

Making a decision involves considering a number of alternatives or options that can best satisfy an objective or goal. This can be accomplished by comparing the alternatives against one another with respect to a set of criteria. The alternative that rates the highest becomes the preferred alternative when this comparison is made.

For the City of Akron, the project team used a computerized statistical method called the Multiple Attribute Analysis Technique to evaluate the five alternatives prepared for the Long Term CSO Control Plan. A brief summary of this evaluation methodology is described in the following paragraphs.

Making a decision for selection of a CSO alternative required comparing the five alternatives. The project team established a set of rating "criteria" to compare the alternatives. For the Akron CSO alternatives, the CSO project team including the City staff and consultants selected the following seven criteria:

1. Storm Water Impacts
2. Water Quality Improvements
3. Operation and Maintenance
4. Costs
5. Public Acceptance
6. Community Improvements
7. Construction Issues

Once the rating criteria were established, the City staff and consulting team defined one or more measurements for each criterion. The engineering analysis performed during the City of Akron CSO planning effort was used to calculate and obtain the values for these measurements. The project team conducted additional analysis where measurements were not readily available.

Finally, the project team and the Technical Advisory Group (consisting of selected community officials, business and community stakeholders, Ohio EPA representatives, and environmental groups) weighted each criteria to account for higher or lower importance assigned to the criteria. The Technical Advisory Group also weighted the measurements assigned to each criterion in a similar manner.

After four iterations with the Technical Advisory Group, a consensus was reached and the project team finalized a hierarchy tree for the evaluation and rating of alternatives shown in Figure 6.

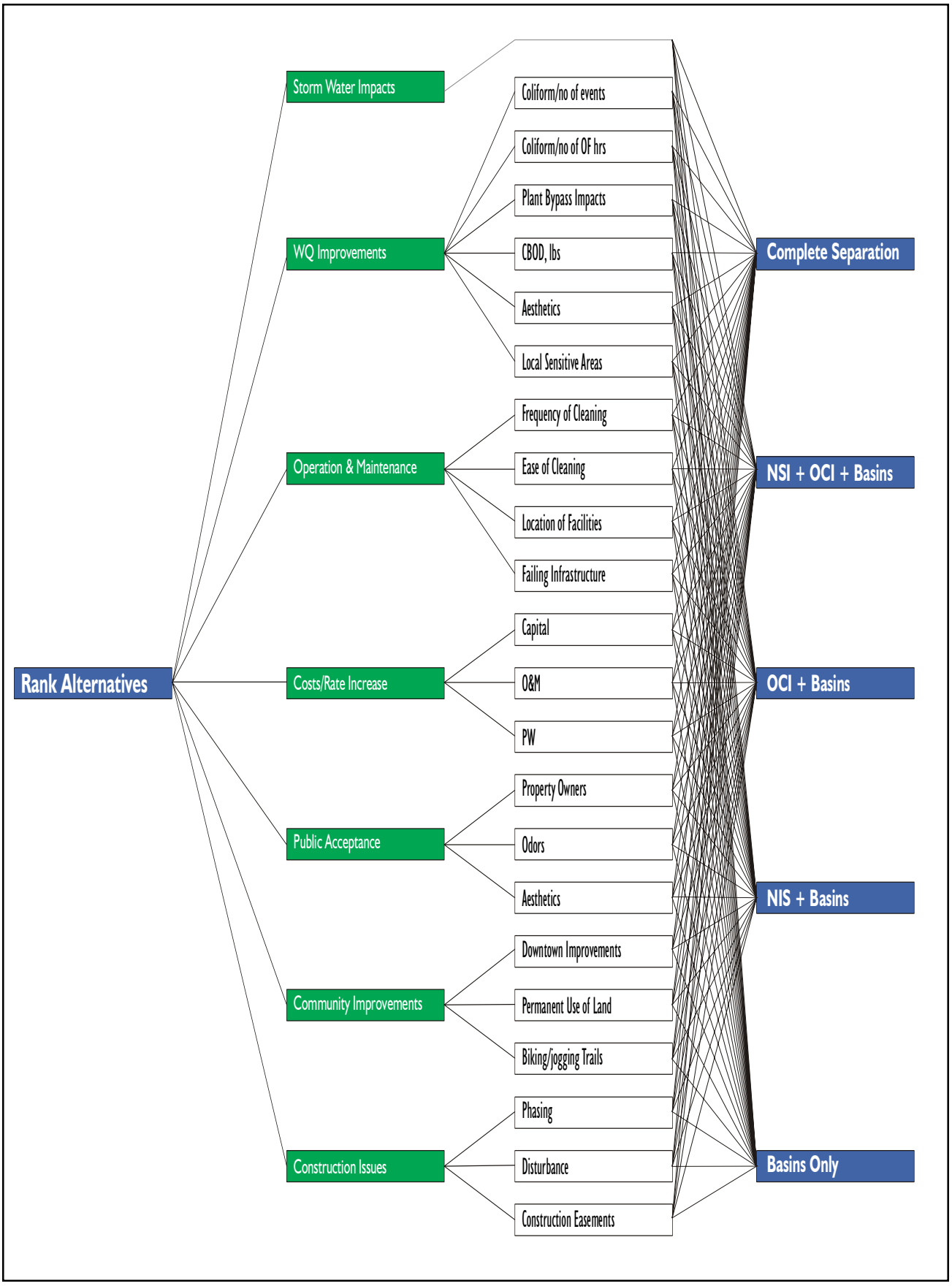


Figure 6 - Hierarchy Tree

The table below presents the criteria and the selected weights for each of the criteria. The weights were from 1 to 4 with 4 being the most significant. Storm water impacts, water quality improvements, and public acceptance were weighed equal (3) while the cost was considered most important (4). Community improvements were next (2.5) and construction issues and operation and maintenance were rated lowest (1).

Criteria	Weights
Storm water impacts	3
Water quality improvements	3
Operation and maintenance	1
Costs	4
Public acceptance	3
Community improvements	2.5
Construction issues	1

The Technical Advisory Group also weighted the measurements for each criterion as shown in Table 6:

Table 6 Assigned Weights for Measurements

Criteria	Measurements	Weights
Storm water impacts	Stormwater Pollutant Loads	3
Water quality improvements	Coliform/no. of events	3
	Coliform/no. of overflow hours	4
	Plant bypass impacts	2
	CBOD, lbs.	5
	Aesthetics	4
	Impact on local sensitive areas	5
Operation and maintenance	Frequency of cleaning	3
	Ease of cleaning	5
	Location of facilities	1
	Improvement of failing infrastructure	5
Costs	Capital	4
	O&M	3
	Present worth	2
Public acceptance	Property owners	3
	Odors	4
	Aesthetics	2
Community improvements	Downtown improvements	3
	Permanent use of land	2
	Bike/jogging trails	5
Construction issues	Phasing	3
	Disturbance	4
	Construction easements	2

Note: Scale from 1 to 5 with 5 being the most significant

Table 7 shows the measurements input into the decision model for this Multiple-attribute Analysis Technique method from the CSO planning reports based on the five alternatives. The objective measurements are marked with an asterisk. These values were determined from previous reports.

Table 7 Values of Measurements Used in the Evaluation Analysis

Criteria	Measurements	Alter. 1 Complete Separation	Alter. 2 NSI+OCI+ Basins	Alter. 3 OCI + Basins	Alter. 4 NSI + Basins	Alter. 5 Detention Basins
Storm water impacts	Stormwater Pollutant Loads (1,000s lbs.)*	370.0	16.0	16.0	18.0	18.0
Water Quality Improvements	Coliform/no. of events*	23.0	115.0	128.0	129.0	145.0
	Coliform/no. of hrs.*	522.0	362.0	431.0	383.0	406.0
	Plant bypass impacts (1,000s lbs.)*	260.0	420.0	490.0	490.0	490.0
	CBOD, lbs. (1,000s lbs.)*	540.0	320.0	400.0	430.0	420.0
	Aesthetics	3.0	3.0	3.0	3.0	3.0
	Local sensitive areas	3.0	3.0	3.0	3.0	3.0
Operation and Maintenance	Frequency of cleaning	1.0	11.0	15.0	17.0	21.0
	Ease of cleaning	4.0	3.0	2.0	2.0	1.0
	Location of facilities	4.0	3.0	2.0	2.0	1.0
	Failing infrastructure	3.0	2.0	1.5	1.5	1.0
Costs	Capital (mil. $)*	998.0	175.0	153.0	111.0	90.0
	O & M (mil. $)*	1.2	1.4	1.3	2.2	2.2
	PW (mil. $)*	869.0	188.0	164.0	145.0	121.0
Public Acceptance	Property owners	1.0	2.0	2.0	2.0	1.0
	Odors	4.0	3.0	2.0	2.0	1.0
	Aesthetics	4.0	3.0	2.0	2.0	2.0
Water Quality Improvements	Downtown improvements	3.0	2.0	3.0	2.0	1.0
	Permanent use of land	3.0	3.0	2.0	2.0	1.0
	Bike/jogging trails	2.0	3.0	2.0	2.0	1.0
Construction Issues	Phasing	3.0	1.0	2.0	2.0	3.0
	Disturbance	1.0	3.0	2.5	2.5	2.0
	Construction easements	1.0	3.0	3.0	3.0	3.0

*** Objective measurement values**

Results of the Evaluation Analysis

The results of the analysis are shown in Figure 7 where all five alternatives are rated between 0 and 1. Alternative No. 2 rated the highest with a score of 0.679. This score indicates that even if the weights of the criteria measurements were modified, Alternative 2 would be the highest rated 67.9% of the time. This alternative is combination of two storage conveyance tunnels (NSI and OCI), sewer separation in 7 CSO contributing areas, and 11 detention basins. Alternative No.1, System-Wide Sewer Separation is rated lowest. The remaining three alternatives are shown to be in between the two.

With the measurements calculated and weighting factors assigned, a spreadsheet matrix was prepared that combined all of these values into a single final rating score for each alternative. All values were normalized between zero and one, with one being the best.

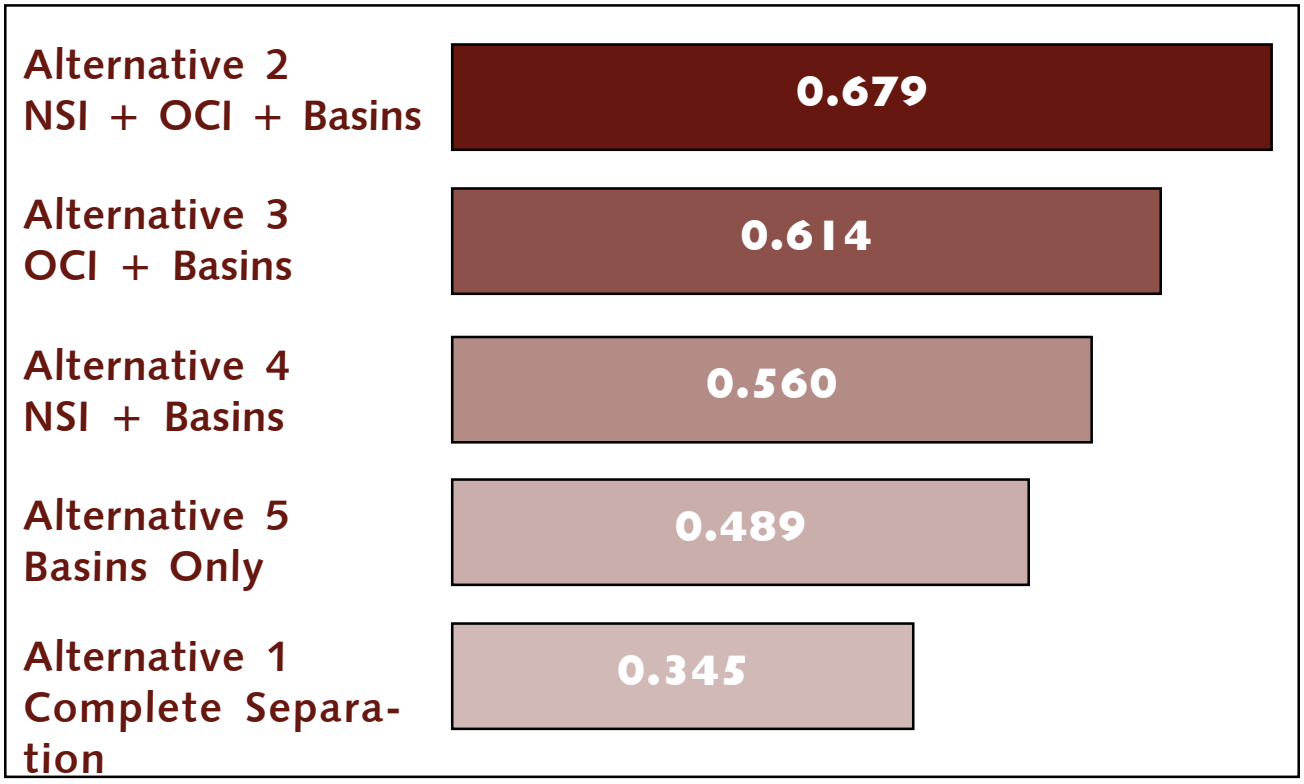


Figure 7 - Rating of Alternatives

Contribution by Criteria

In any decision, some criteria contribute more towards the results than others do. Contribution by criteria in the rating of Akron alternatives is shown in Figure 8. The figure shows which criteria made the most contribution and which made the least in ranking of alternatives.

Figure 8 shows histograms of the accumulated values of the alternatives, broken down by the contribution (shown as a color-coded strip) of the five most significant criteria selected to evaluate the alternatives. The accumulated values are the decision scores. The height of each strip indicates its contribution. For example, the capital cost of Sewer Separation Alternative No.1 is the highest ($ 998 million) and is indicated by the shortest strip as compared to other alternative histograms. Larger strips indicate greater benefits.

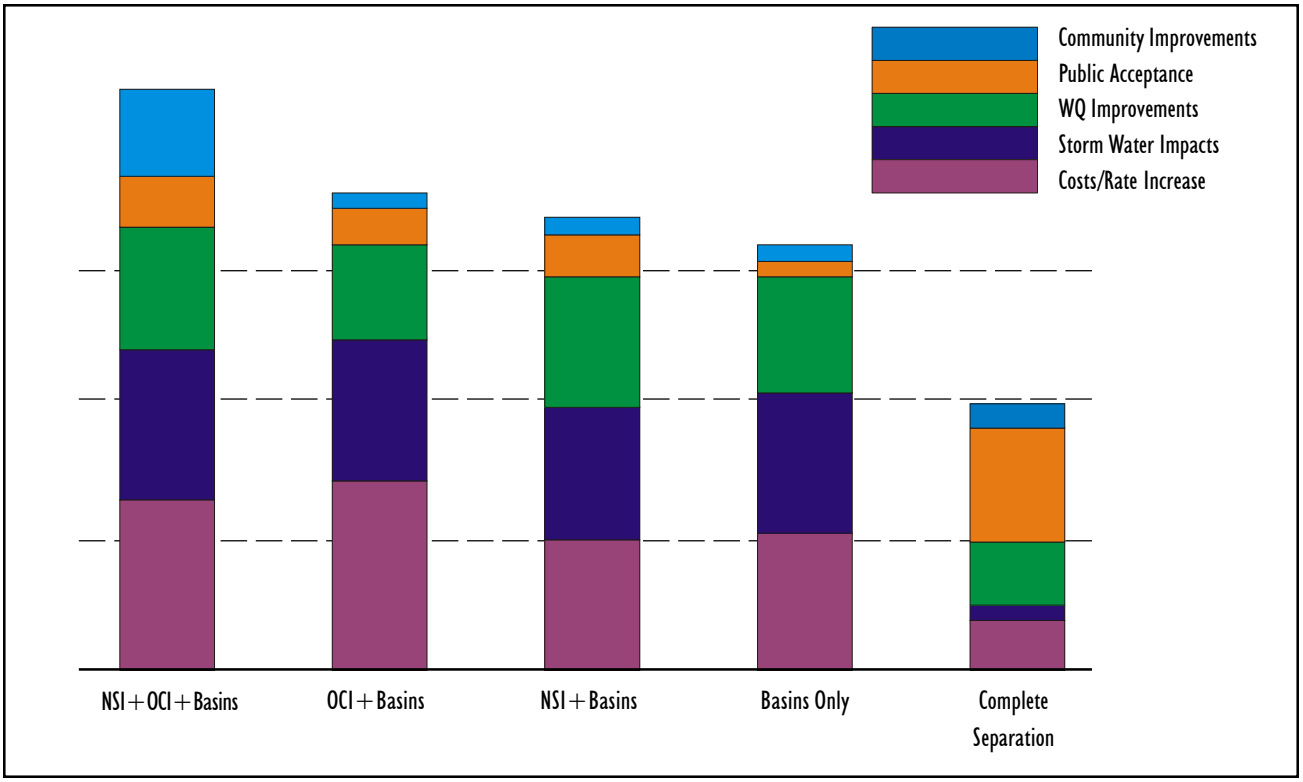


Figure 8 - Contributions by Criteria for Alternative Rating

Sensitivity of Assigned Weights

Another way to analyze these results is to look at the sensitivity of the assigned weights for each criterion. Figure 9 tests how sensitive the results are to changes in weights. Figure 9 shows this sensitivity for cost which were the criteria with the greatest weight value, similar sensitivity diagrams can be shown for all other criteria.

The vertical axis in Figure 9 represents the decision score and the horizontal axis represents the range of values over which the weight of the criteria is varied. The red vertical line shows the current assigned value (0.25) while the sloping lines in different colors represent the alternatives.

At this weight the selected alternative is Alternative No. 2. However, if the weight of the Cost Criteria was increased to greater than 0.8, the preferred alternative would be No. 3 as shown by the dotted vertical line. The figure indicates that Alternative No. 2 is the preferred alternative over the wide range of weights between 0 – 0.7.

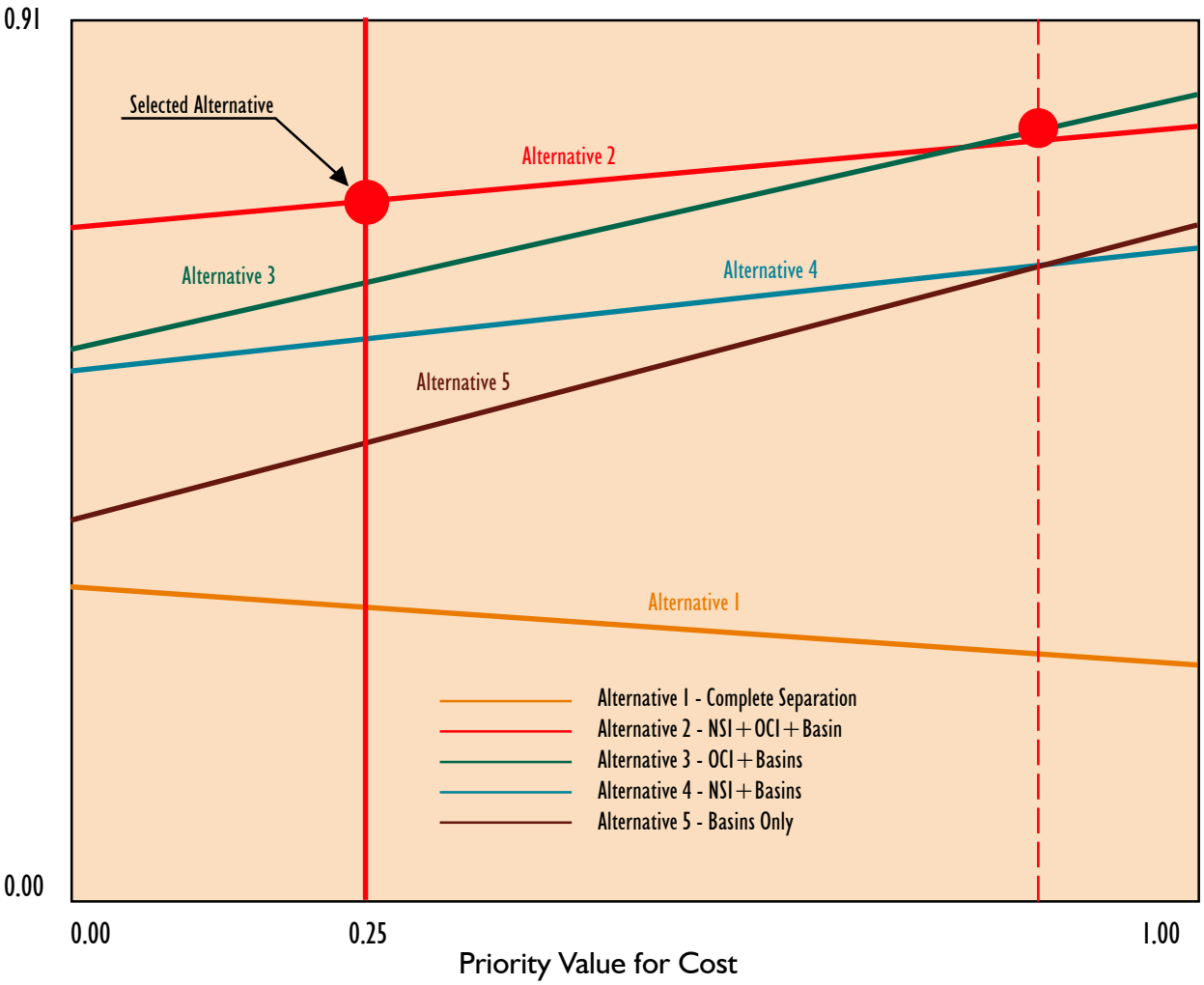
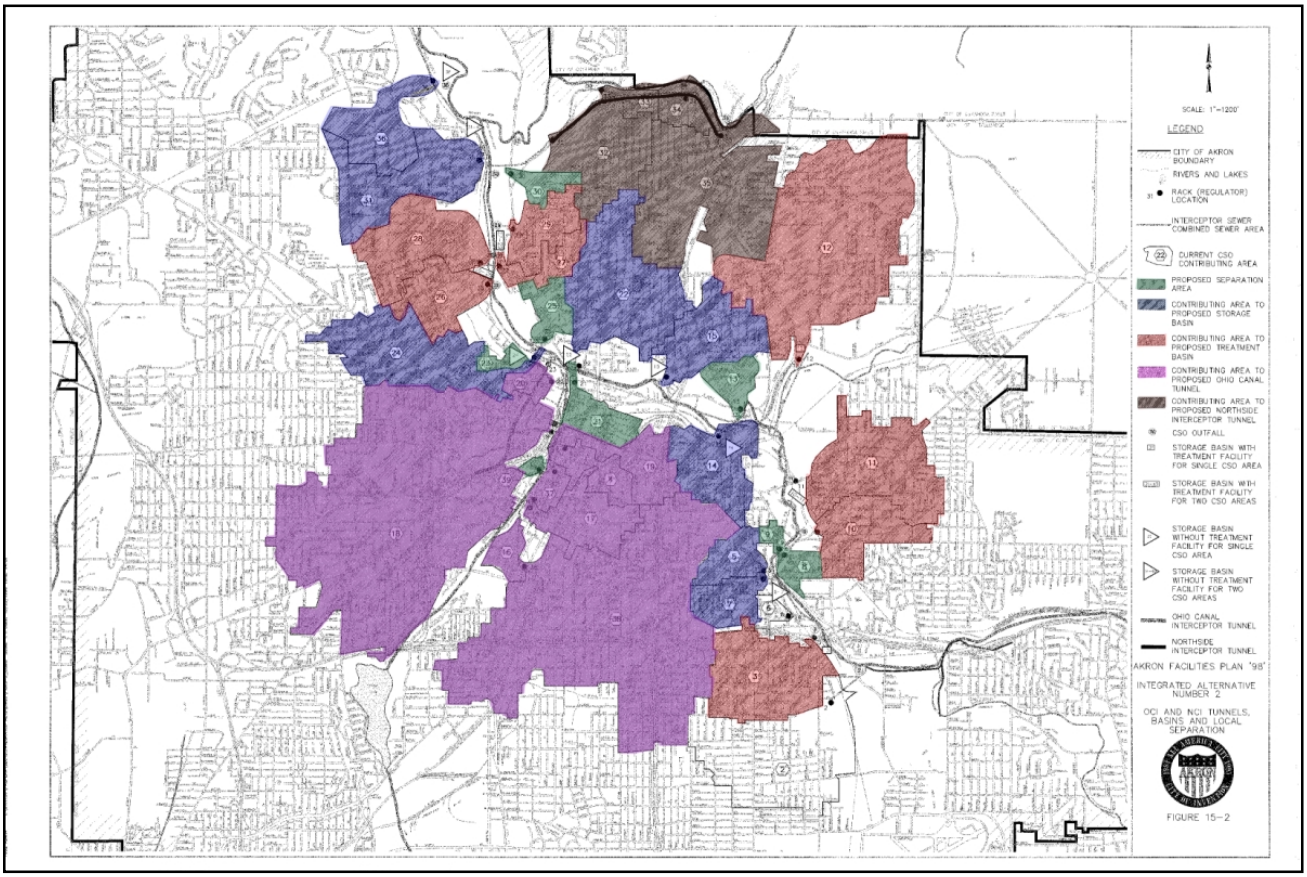


Figure 9 - Sensitivity of Alternatives' Decision Scores to Weights

Conclusion

Based on the discussions with the City of Akron staff, the Technical Advisory Group and the measurements obtained from the City CSO Planning Reports, as indicated in Figures 7 and 8, the preferred alternative is Alternative No. 2. This alternative is a combination of storage/conveyance tunnels, sewer separation in 7 CSO contributing areas, and 11 detention basins.

The Ohio Canal Interceptor (OCI) Tunnel would serve Racks 4, 16, 17, 18, 19, 20, 23, 24, 37, 38, a portion of 21 and the Northside (NSI) Tunnel would serve Racks 32, 33, 34, and 35. Sewer separation would be performed in areas tributary to Racks 8, 9, 13, 25, 30, 39, and a portion of 21. Detention basins would be constructed for Racks 3, 5/7, 10/11, 12, 14, 15, 22, 26/28, 29/27, 31/40, and 36.



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